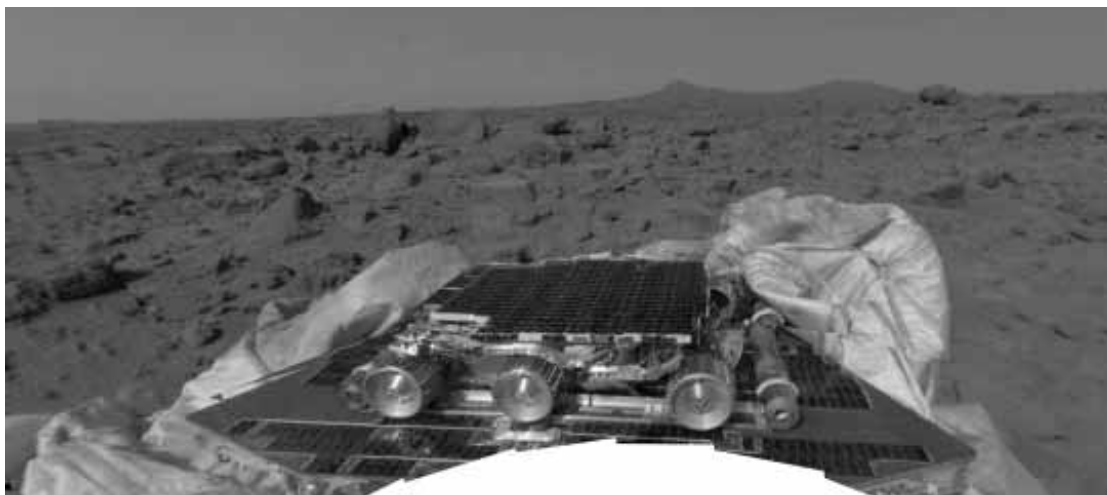




National Aeronautics and  
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Educational Product	
Teachers and Students	Grades K– Postdoctoral

## Mars Pathfinder Lithograph Set



### This set contains the following materials:

- Introduction/NASA Resources for Educators
- Litho: “Mars Pathfinder’s Landing Site—July 4, 1997”
- Litho: “Six Wheels on Soil”
- Litho: “Sojourner’s Exploration of Mars”
- Litho: “Ares Vallis, Mars”

### Other Mars Pathfinder Materials Available:

**POSTER:** “Mars Pathfinder—Roving the Red Planet”  
(panorama of landscape/rover) To obtain copies, please  
contact the nearest NASA Educator Resource Center  
(see other side of this page for info).

**SLIDE SET:** “Mars Pathfinder/Sojourner: Success” (20 slides)

Order from:

- NASA Central Operation of Resources  
for Educators (CORE)  
*Phone:* 1-440-774-1051, ext. 249/293  
(see other side for more info)
- Finley-Holiday Film Corporation  
*Phone:* 1-800-345-6707  
*Internet:* <http://www.finley-holiday.com>  
*Write:* Box 619, Whittier, CA 90601

### For more information about Mars Pathfinder:

**Internet:** Mars Pathfinder:  
<http://mpfwww.jpl.nasa.gov>  
NASA Office of Space Science:  
<http://www.nasa.gov/office/oss/>

**Phone:** Daily Mission Updates:  
1-800-391-6654

**Mail:** Jet Propulsion Laboratory  
Public Services Office  
Mail Stop 186  
4800 Oak Grove Dr.  
Pasadena, CA 91109

# NASA Resources for Educators

**NASA's Central Operation of Resources for Educators (CORE)** was established for the national and international distribution of NASA-produced educational materials in audiovisual format. Educators can obtain a catalog and an order form by one of the following methods:

- **NASA CORE**  
Lorain County Joint Vocational School  
15181 Route 58 South  
Oberlin, OH 44074
- Phone: (440) 774-1051, ext. 249 or 293
- Fax: (440) 774-2144
- E-mail: [nasaco@leeca8.leeca.ohio.gov](mailto:nasaco@leeca8.leeca.ohio.gov)
- Home Page: <http://spacelink.nasa.gov/CORE>

## Educator Resource Center Network

To make additional information available to the education community, the NASA Education Division has created the NASA Educator Resource Center (ERC) network. ERCs contain a wealth of information for educators: publications, reference books, slide sets, audio cassettes, videotapes, telelecture programs, computer programs, lesson plans, and teacher guides with activities. Educators may preview, copy, or receive NASA materials at these sites. Because each NASA Field Center has its own areas of expertise, no two ERCs are exactly alike. Phone calls are welcome if you are unable to visit the ERC that serves your geographic area. The following is a list of the centers and the regions they serve:

*AK, AZ, CA, HI, ID, MT, NV, OR, UT, WA, WY*  
NASA Educator Resource Center  
Mail Stop 253-2  
**NASA Ames Research Center**  
Moffett Field, CA 94035-1000  
Phone: (415) 604-3574

*CT, DE, DC, ME, MD, MA, NH, NJ, NY, PA, RI, VT*  
NASA Educator Resource Laboratory  
Mail Code 130.3  
**NASA Goddard Space Flight Center**  
Greenbelt, MD 20771-0001  
Phone: (301) 286-8570

*CO, KS, NE, NM, ND, OK, SD, TX*  
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Mail Code AP-2  
**NASA Johnson Space Center**  
2101 NASA Road One  
Houston, TX 77058-3696  
Phone: (281) 483-8696

*FL, GA, PR, VI*  
NASA Educator Resource Laboratory  
Mail Code ERL  
**NASA Kennedy Space Center**  
Kennedy Space Center, FL 32899-0001  
Phone: (407) 867-4090

*KY, NC, SC, VA, WV*  
Virginia Air and Space Museum  
NASA Educator Resource Center for  
**NASA Langley Research Center**  
600 Settler's Landing Road  
Hampton, VA 23669-4033  
Phone: (757) 727-0900 x 757

*IL, IN, MI, MN, OH, WI*  
NASA Educator Resource Center  
Mail Stop 8-1  
**NASA Lewis Research Center**  
21000 Brookpark Road  
Cleveland, OH 44135-3191  
Phone: (216) 433-2017

*AL, AR, IA, LA, MO, TN*  
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NASA Educator Resource Center for  
**NASA Marshall Space Flight Center**  
P.O. Box 070015  
Huntsville, AL 35807-7015  
Phone: (205) 544-5812

*MS*  
NASA Educator Resource Center  
Building 1200  
**NASA John C. Stennis Space Center**  
Stennis Space Center, MS 39529-6000  
Phone: (601) 688-3338

NASA Educator Resource Center  
JPL Educational Outreach  
Mail Stop CS-530  
**NASA Jet Propulsion Laboratory**  
4800 Oak Grove Drive  
Pasadena, CA 91109-8099  
Phone: (818) 354-6916

*CA cities near the center*  
NASA Educator Resource Center for  
**NASA Dryden Flight Research Center**  
45108 N. 3rd Street East  
Lancaster, CA 93535  
Phone: (805) 948-7347

*VA and MD's Eastern Shores*  
NASA Educator Resource Lab  
Education Complex - Visitor Center  
Building J-1  
**NASA Wallops Flight Facility**  
Wallops Island, VA 23337-5099  
Phone: (757) 824-2297/2298

**Regional Educator Resource Centers (RERCs)** offer more educators access to NASA educational materials. NASA has formed partnerships with universities, museums, and other educational institutions to serve as RERCs in many states. A complete list of RERCs is available through CORE, or electronically via NASA Spacelink at <http://spacelink.nasa.gov>

**NASA On-line Resources for Educators** provide current educational information and instructional resource materials to teachers, faculty, and students. A wide range of information is available, including science, mathematics, engineering, and technology education lesson plans, historical information related to the aeronautics and space program, current status reports on NASA projects, news releases, information on NASA educational programs, useful software, and graphics files. Educators and students can also use NASA resources as learning tools to explore the Internet, accessing information about educational grants, interacting with other schools that are already on-line, participating in on-line interactive projects, and communicating with NASA scientists, engineers, and other team members to experience the excitement of real NASA projects.

Access these resources through the NASA Education Home Page: <http://www.hq.nasa.gov/education>

**NASA Television (NTV)** is the Agency's distribution system for live and taped programs. It offers the public a front-row seat for launches and missions, as well as informational and educational programming, historical documentaries, and updates on the latest developments in aeronautics and space science. NTV is transmitted on the GE-2 satellite, Transponder 9C at 85 degrees West longitude, vertical polarization, with a frequency of 3880 megahertz and audio of 6.8 megahertz.

Apart from live mission coverage, regular NASA Television programming includes a Video File from noon to 1:00 p.m., a NASA Gallery File from 1:00 to 2:00 p.m., and an Education File from 2:00 to 3:00 pm (all times Eastern). This sequence is repeated at 3:00 p.m., 6:00 p.m., and 9:00 p.m., Monday through Friday. The NTV Education File features programming for teachers and students on science, mathematics, and technology. NASA Television programming may be videotaped for later use.

For more information on NASA Television, contact:  
NASA Headquarters, Code P-2, NASA TV, Washington, DC 20546-0001  
Phone: (202) 358-3572  
NTV Home Page: <http://www.hq.nasa.gov/ntv.html>

## How to Access NASA's Education Materials and Services, EP-1996-11-345-HQ

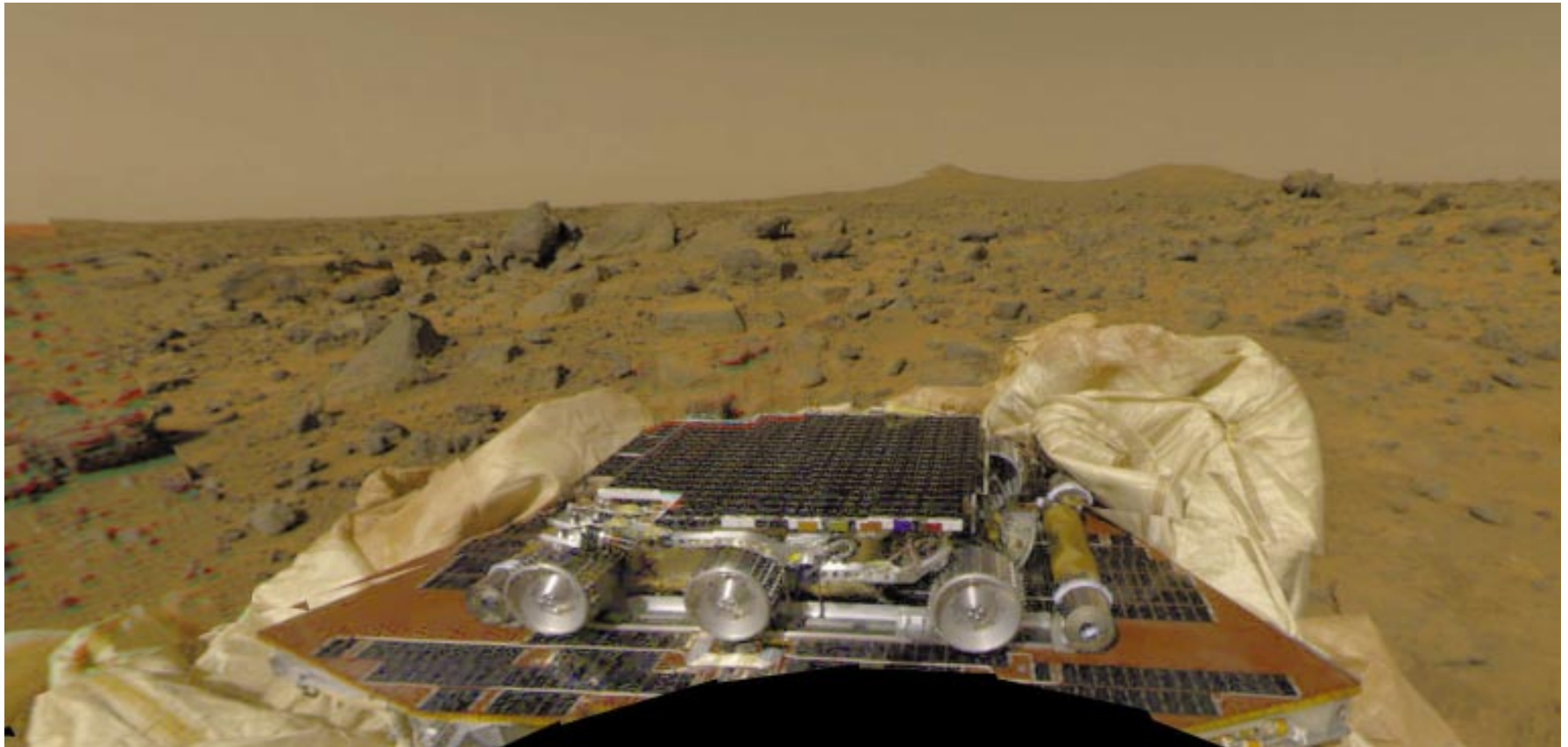
This brochure serves as a guide to accessing a variety of NASA materials and services for educators. Copies are available through the ERC network, or electronically via NASA Spacelink. NASA Spacelink can be accessed at the following address:  
<http://spacelink.nasa.gov>





National Aeronautics and  
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## Mars Pathfinder's Landing Site—July 4, 1997





National Aeronautics and  
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## Mars Pathfinder's Landing Site—July 4, 1997

**A**t 10 o'clock in the morning, U.S. Pacific Daylight Time, on July 4, 1997, the Mars Pathfinder spacecraft bounced to a stop on Mars, the first visit by a U.S. spacecraft to the surface of Mars since the Viking missions of 1976. Mars Pathfinder landed at a site known as Ares Vallis (Mars Valley) in a region called Chryse Planitia (Plains of Gold).

The spacecraft's entry, descent, and landing sequence demonstrated many engineering techniques that can now be used on subsequent planetary missions. Mars Pathfinder used a combination of a heatshield, parachute, and rockets, to slow its descent through the thin atmosphere. The lander,

encased in airbags similar to those found in automobiles but much larger and designed for the Martian environment, bounced at least 16 times and for at least a minute and a half before coming to rest right-side up. Local Mars time at Ares Vallis was about 3:00 a.m., so these events occurred in the dark.

Once at rest, the lander unfolded its petals and retracted the deflated airbags. Right on schedule, it sent a beacon signal indicating its progress to the antennas of NASA's Deep Space Network. When the Sun rose, about three hours after the landing, Mars Pathfinder turned on its transmitter and began to send detailed engineering data about its health and its descent through the atmosphere via the low-data-rate antenna.

Later that day, the lander's high-data-rate antenna was pointed at Earth, and the first pictures from the surface of Mars in almost two decades began to flow in to controllers at the Jet Propulsion Laboratory (JPL) in Pasadena, California. The Imager for Mars Pathfinder, or "IMP" camera, returned many small frames that were mosaiced into this panoramic view. The IMP camera imaged the entire surrounding area from its position on top of the lander.

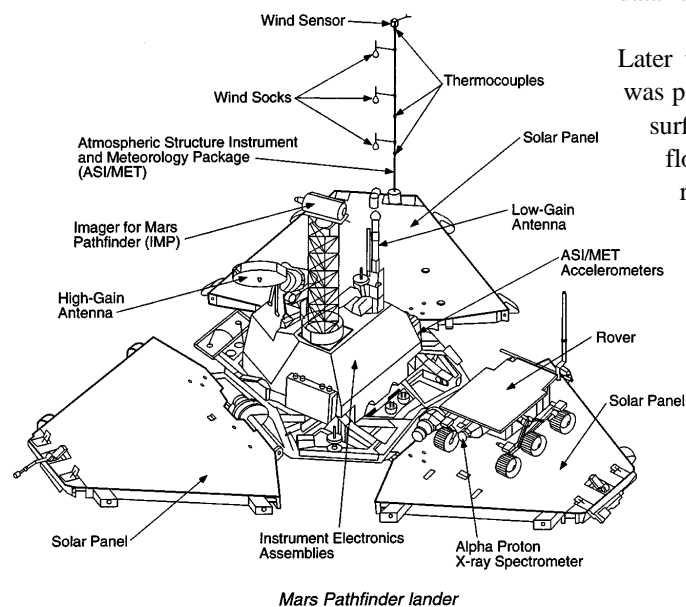
This view is to the west. A great flood of water washed over this region long ago, passing from left to right across this portion of the landscape. The Twin Peaks on the horizon are just about 1 kilometer (0.6 miles) away.

Named after Sojourner Truth, an African-American abolitionist and champion of women's rights during the Civil War era, the rover is still crouched on one of the lander petals. Airbag material billows out from beneath the petal. Rolled into tight cylinders at either end of Sojourner are the undeployed rover ramps. Early images were used to help rover engineers determine which direction was better suited for a safe rolloff. The images revealed that the airbags would interfere with proper deployment; a portion of the airbag is lying on top of one end of the ramp at Sojourner's right. The slight offset in the appearance of the ramp is caused by the way that separate images were patched together.

Late on July 4, JPL flight controllers sent commands to the lander to raise the rover petal, with Sojourner still firmly attached, reel in more of the airbags, and lower the petal back down level with the ground. This maneuver was successfully carried out, and the next day Sojourner rolled onto the surface of Mars to begin her mission of exploration.

This image and additional information about the Mars Pathfinder mission can be found on the Internet at: <http://mpfwww.jpl.nasa.gov>

The Mars Pathfinder mission is part of a long-term program of Mars exploration being conducted by NASA's Office of Space Science. JPL, an operating division of the California Institute of Technology, manages the Mars Exploration Program for NASA.





National Aeronautics and  
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## **“Six Wheels on Soil”**



## “Six Wheels on Soil”

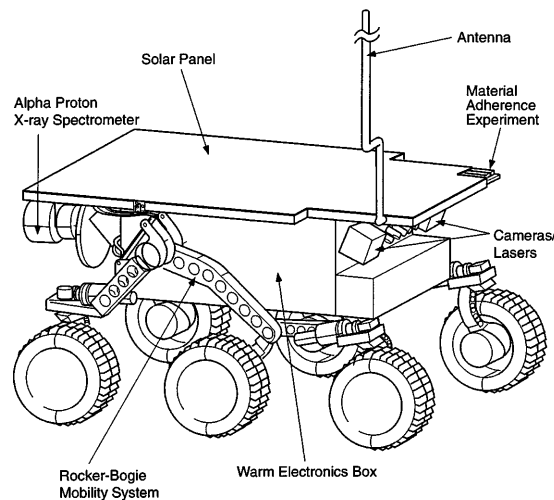
**T**his two-frame mosaic of images from Mars Pathfinder’s camera shows the Sojourner rover after driving onto the Martian surface. When this event occurred late on the night of July 5, 1997 (Pacific Daylight Time), Sojourner became the first autonomous robot to traverse the surface of Mars.

During the trip from Earth to Mars, which began December 4, 1996, and ended July 4, 1997, the rover remained firmly attached to one of the lander’s petals. Once on Mars, the lander opened its petals, and the Imager for Mars Pathfinder (IMP) camera photographed the rover and the surrounding “marscape.” After commanding the lander to lift the rover’s petal to clear some airbag material, the rover team at the Jet Propulsion Laboratory determined that the terrain on each side of the petal was acceptable for a safe rover rolloff down one of the ramps.

Sojourner was then released from the lander petal and rose up to her full height. Both ramps were successfully deployed, but the end of the forward ramp did not actually touch the planet’s surface. Because of the better view of the rear ramp and the interesting rocks and soil that could be seen, the team elected to roll Sojourner backwards off the rear ramp. The end of the ramp can be seen at lower left.

The ramps get their shape and strength from sheets of metal that were flattened into tight rolls. After their restraints were cut, they assumed their original tubular shape and became rigid. The rover’s wheels,

three on each side, straddled the outside of each tube so that Sojourner would not tip or turn.



*Mars Pathfinder's Sojourner rover*

Under power from its electric motors, Sojourner six-wheeled down the ramp and onto the soil of Mars. The “rocker-bogie” suspension system was immediately put to the test. As the far set of wheels (at left in the picture) left the ramp, they encountered a small rock. The suspension system neatly carried the rover over the rock, as can be seen by the wheel tracks on the fine surface material. The tracks run from the end of the ramp for a few centimeters, abruptly end, and continue on the far side of the rock where the wheel stopped. No such obstacle was encountered by the other set of wheels, but traveling over the rock did cause the rover to fishtail slightly and turn a bit to the left.

The dark surface on top of Sojourner is her solar panel, which, along with non-rechargeable batteries, provides electrical power for her operation. The rover measures 65 centimeters (2 feet) long, 48 centimeters (1.5 feet) wide, and 30 centimeters (1 foot) tall. On Mars she weighs 4 kilograms (8.8 pounds) compared to 10.5 kilograms (23 pounds) on Earth.

The shadow of the rock known as Barnacle Bill, the first rock studied by Sojourner, can be seen in the upper left corner. Patches of very fine-grained material can be seen on either side of the rover. Below Barnacle Bill there are a number of small pebbles with streaks of material trailing off to the left. At some point, perhaps during one of Mars’ periodic dust storms, winds blew across this surface from right to left, depositing dust finer than talcum powder on the wind-shadowed side of the pebbles. Mars Pathfinder has observed variable wind speeds and directions; these winds will eventually alter or erase Sojourner’s tracks.

This image and additional information about the Mars Pathfinder mission can be found on the Internet at: <http://mpfwww.jpl.nasa.gov>.

The Mars Pathfinder mission is part of a long-term program of Mars exploration being conducted by NASA’s Office of Space Science. The Jet Propulsion Laboratory, an operating division of the California Institute of Technology, manages the Mars Exploration Program for NASA.



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## Sojourner's Exploration of Mars



**Sojourner at "Barnacle Bill"**



**Soil Measurements**



**Rover's-Eye View of Lander**



**Sojourner Does a Wheelie at "Yogi"**



**T**hese four images highlight the types of scientific experiments and engineering tests that the rover Sojourner has conducted on Mars. Three of the images were taken by the Imager for Mars Pathfinder (IMP) camera. A fourth image was taken by one of the three cameras on board the rover.

## Sojourner at “Barnacle Bill”

Sojourner's first analysis of a rock on Mars began on Sol 3 (Mars Pathfinder's third Martian day) with the study of Barnacle Bill, a nearby rock named for its rough surface. The Alpha Proton X-ray Spectrometer (APXS) is used to determine the elements that make up the rocks and soil on Mars. A full study using the APXS takes approximately 10 hours. It measures all elements, except hydrogen, as long as they make up at least 1/10th of 1 percent of the mass of the rock or soil. The APXS conducts its studies by bombarding rocks and soil samples with alpha particle radiation—charged particles equivalent to the nucleus of a helium atom, consisting of two protons and two neutrons. Results indicated that Barnacle Bill is similar in composition to Earth rock known as andesite. On Earth, andesite is produced through repeated cycles of melting and solidification, such as volcanic activity.

## Soil Measurements

This image was taken by the IMP camera on Sol 4. Sojourner has traveled to an area of soil and several rocks. Rover tracks are clearly visible in the soft soil seen in the foreground, and were made in part by the rover's material abrasion experiment. Scientists were able to control the force of the rover's cleated wheels to help determine the physical properties of the soil. In this image, Sojourner has lowered its APXS instrument to the surface to study an area of soil. A small portion of the rock Yogi and its shadow can be seen in the upper right corner. The three rocks just above and to the left of Sojourner's solar panel are called The Dice.

## Rover's-Eye View of Lander

On Sol 26 one of the two forward facing cameras aboard the Sojourner rover took this image of the lander, which has been named the Carl Sagan Memorial Station after the late astronomer. Features seen on the lander include (from left to right) the Atmospheric Structure Instrument/Meteorology Package (ASI/MET) mast with windsocks, the low-gain antenna mast, the disc-shaped high-gain antenna angled off to the right and pointed at Earth, and areas of deflated airbags. The dark circle on the

lander body is a filtered vent that allowed air to escape during launch, and allowed the lander to repressurize upon landing. Mini Matterhorn is the large rock in front of the lander to the left.

## Sojourner Does a Wheelie at Yogi

Sojourner has made contact with the rock Yogi in this image, taken on Sol 6. The rover's left rear wheel has driven up onto Yogi's surface in an attempt to get as close as possible to the rock's surface. Sojourner later drove off Yogi and returned at a slightly different angle, placing its APXS instrument against the rock to conduct a study of its chemical composition. This observation indicated that Yogi has had a different geological history than Barnacle Bill; it is a more primitive basaltic igneous rock.

These images and additional information about the Mars Pathfinder mission can be found on the Internet at: <http://mpfwww.jpl.nasa.gov>

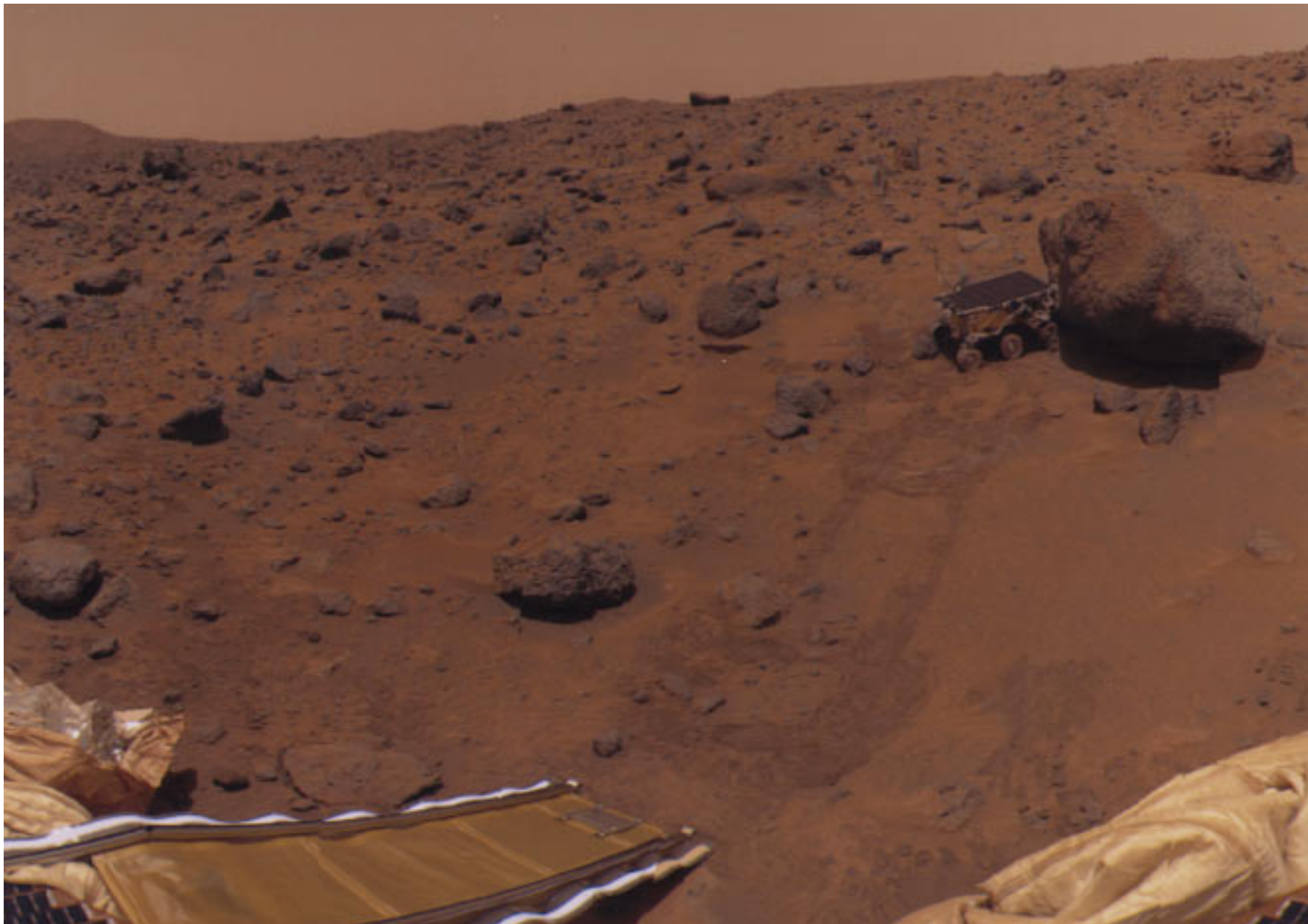
The Mars Pathfinder mission is part of a long-term program of Mars exploration being conducted by NASA's Office of Space Science. The Jet Propulsion Laboratory, an operating division of the California Institute of Technology, manages the Mars Exploration Program for NASA.





National Aeronautics and  
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## Ares Vallis, Mars





**T**his image is a portion of a full-color panorama. This portion covers about one quarter of the surrounding “marscape” of Ares Vallis (Mars Valley). Visible next to the rock named Yogi is the rover Sojourner. She has backed up to Yogi and has placed the Alpha Proton X-ray Spectrometer instrument against the rock in order to determine its elemental composition. Yogi is approximately 6.5 meters (20 feet) from the Mars Pathfinder lander and stands about 1 meter (3 feet) high. Sojourner is 30 centimeters (1 foot) tall.

In the lower left corner of the image is the ramp that Sojourner used to roll off the lander petal and onto the Martian soil. To the right is part of the deflated airbags from the adjacent petal. Sojourner’s tracks across the soil are plainly visible and are darker than the undisturbed soil. The dark streaks on the soil above the airbags were caused when the airbags were reeled in during the first hours after landing on July 4, 1997. In two locations, near the end of the ramp and on the way to Yogi, disturbed dust shows where Sojourner made pivoting turns.

A dusting of very fine-grained material is also seen on a number of the rocks in the view. Dust has gathered to the left of Barnacle Bill, the pitted football-shaped and -sized rock above the end of the ramp. The wind on Mars can carry only very lightweight and fine-grained dust—although the wind can blow at speeds of hundreds of kilometers per hour, it does not have much force because of the thin atmosphere. (Such wind speeds have not been observed by Mars Pathfinder.) Some of the talcum powder-like dust can be seen on the rover’s wheels, and suspended dust particles give the sky its color.

At one time in Mars’ past, a large amount of water rushed across this area. The direction of flow was to the north, which is toward the upper right corner in this picture. The flood waters cut a series of gullies in the plain. The gullies line up in the direction of the water flow. A trek across this “marscape” toward the horizon would carry you up and down a series of hills and valleys.

On the horizon is the rock known as the Couch. Most rocks are informally named for their appearance by scientists to make them easy to identify during team meetings and public

discussions. The Couch is more than 150 meters (500 feet) away. The Imager for Mars Pathfinder stereo camera, which took this image, allows team members to measure distances to about 150 meters. But they must estimate distances beyond that—unless a feature can be identified from images taken by one or both Viking orbiting spacecraft.

Viking Orbiters 1 and 2 photographed the planet between July 1976 and August 1980. Orbital views of the Mars Pathfinder landing region show two features now known as the Twin Peaks. In the upper left corner of this view is the North Peak. It is 0.86 kilometers (0.53 miles) away from the lander.

This image and additional information about the Mars Pathfinder mission can be found on the Internet at: <http://mpfwww.jpl.nasa.gov>.

The Mars Pathfinder mission is part of a long-term program of Mars exploration being conducted by NASA’s Office of Space Science. The Jet Propulsion Laboratory, an operating division of the California Institute of Technology, manages the Mars Exploration Program for NASA.

# Mars Pathfinder Lithograph Set

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***[http://ednet.gsfc.nasa.gov/edcats/lithograph\\_set](http://ednet.gsfc.nasa.gov/edcats/lithograph_set)***

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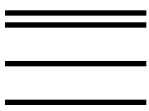
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